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Lightning Injury With Survival in Five Patients

Brian W. Army, MD; William F. McManus, MD; Cleon W. Goodwin, Jr, MD; Basil A. Pruitt, Jr, MD

Of a total of 4,153 admissions, five patients with lightning-associated injuries were admitted to a burn center during a 15-year period, 1969 through 1983. In these patients, the burned portion of the total body surface ranged from 3% to 19% (average, 16%), and all survived. The associated injuries and complications in these lightning-strike victims and a review of treatment guidelines are presented.

(JAMA 1985;253:243-245)

Their treatment and hospital courses are described, along with comments on the pathophysiology of such injuries and a review of treatment recommendations. If present, serious complications such as myoglobinuria, cardiac arrhythmias, fractures, abnormal neurological symptoms, or visual or auditory aberrations experienced during the hospital course are cited.

Report of Cases

CASE 1.—A 16-year-old boy sustained a 23% total body surface (TBS) burn when he was struck by lightning. The lightning bolt first struck a television antenna on a nearby trailer, arced, and struck him. He was thrown to the ground with his clothing aflame. He did not lose consciousness and was immediately transported to a hospital. En route, premature ventricular contractions were noted on the cardiac monitor, but his ECG reverted to normal sinus rhythm on arrival at the hospital. His condition remained stable, and after administration of intravenous fluids was initiated, he was transferred to our burn

LIGHTNING injury is uncommon, as evidenced by the fact that most physicians have never treated such a victim, but its rarity does not diminish the interest in, or severity of, this fascinating injury. Reports of lightning injuries range from the anecdotal to

collective reviews of large numbers of patients injured in natural electrocutions.¹ The physician must understand the pathophysiology, treatment, and initial and potential complications of this severe form of high-voltage electric injury to treat patients with such injury effectively.

There were 4,153 admissions to the US Army Institute of Surgical Research Burn Center during a 15-year period, 1969 through 1983, of which five were for lightning-associated injuries. These five patients survived; all were treated and resuscitated appropriately on arrival at each of the respective receiving hospitals.

From the US Army Institute of Surgical Research, Brooke Army Medical Center, Fort Sam Houston, Tex.

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Reprint requests to Library, US Army Institute of Surgical Research, Brooke Army Medical Center, Fort Sam Houston, TX 78234 (Dr McManus).

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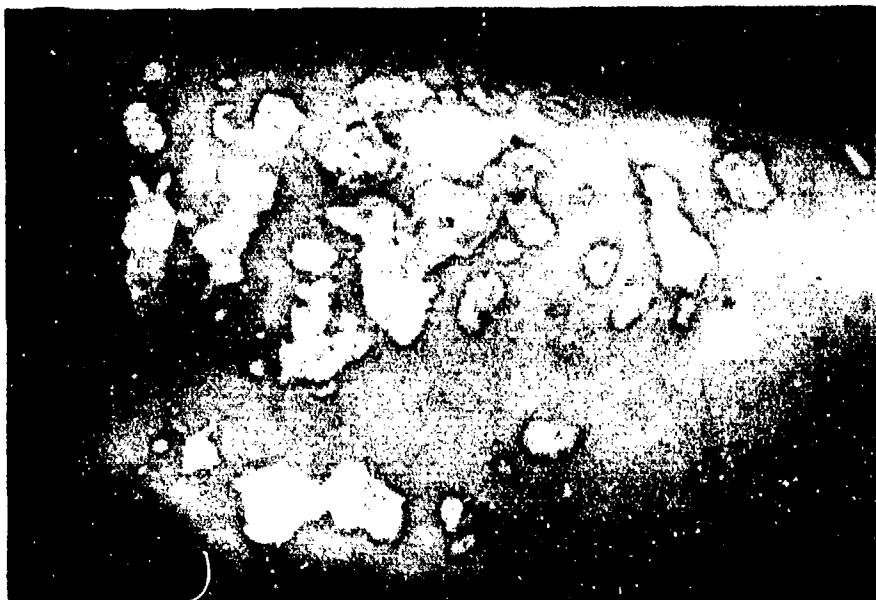


Fig 1.—Patient 1 had 23% total body surface area burn with characteristic arborizing dermal burn pattern on posterior side of trunk. Photograph was taken on fourth postburn day.



Fig 2.—Patient 4 had 12% total body surface area burn with serpiginous dermal pattern on posterior side of trunk. Photograph was taken on second postburn day.

center. On arrival, his physical examination was remarkable only for the 23% TBS injury (Fig 1). He did not experience any serious complications, and cardiac follow-up demonstrated neither dysrhythmias nor any evidence of myocardial infarction during his 61-day hospital course. He underwent five procedures to debride, excise, and autograft the third-degree burns (11% TBS) on his buttocks, right thigh, and right calf. He was discharged fully epithelialized and without apparent complications or sequelae.

CASE 2.—A 31-year-old woman sustained a 3% TBS burn after a lightning strike. She was outside in the rain when lightning struck the metal umbrella in her right hand. She did not lose consciousness and was transported to a hospital. She had an arborizing pattern of partial-thickness

burns on the palm of her right hand, right arm, right side of the chest, and right flank. An ECG was interpreted as showing normal sinus rhythm. On arrival at our burn center, her physical examination was remarkable only for an entrance wound of the right palm and a 3% TBS burn, which seemed to be deep partial thickness in the aforementioned areas, as well as some first-degree burns of the lower part of the neck. Although her initial neurological examination demonstrated no loss of sensory or motor function, a mild median nerve deficit, which was confirmed by electromyogram (EMG), developed during her 19-day hospital course. The burned areas of the right hand healed spontaneously with application of porcine cutaneous xenograft as a biological dressing. She was discharged fully epithelialized

and with mild median nerve deficit.

CASE 3.—A 22-year-old man sustained a 14% TBS burn when he and 20 other soldiers were standing near a tree as it was struck by lightning. Many of the men suffered a brief shock, but only this patient received serious injuries. He allegedly lost consciousness for two to three minutes. He was resuscitated at a hospital and underwent bilateral lower-extremity fasciotomies. On arrival at our burn center, his physical examination was remarkable for four small entry burns on the right flank; both feet and both legs were grossly edematous; fasciotomy incisions were present bilaterally; distal pulses were palpable; and exit wounds were noted on the toes of both feet and on the dorsum of the right foot. There was no plantar sensation in either foot. The patient did not experience any serious complications during his 65-day hospital course. He regained sensation in both feet and ambulated early; the fasciotomies healed secondarily; and areas of third-degree burn were excised and autografted. He was discharged fully healed.

CASE 4.—A 14-year-old boy sustained a 12% TBS burn when a lightning bolt struck the bathroom in which he was seated. The associated explosion blew off the bathroom's outer wall, and the patient was found semicomatose. He was resuscitated, and there was ECG evidence of subendocardial myocardial infarction. On physical examination, he had bilateral perforated tympanic membranes, normal sensorium and neurological examination findings, and a partial-thickness burn in a serpiginous pattern extending down the anterior and posterior sides of the trunk (Fig 2). He was transferred to our burn center on the third postburn day in stable condition. No other symptoms or complications developed during his hospital course, and his burns healed spontaneously. He was discharged with persistent but not progressive ECG evidence of subendocardial infarction and decreased auditory acuity secondary to bilateral perforated tympanic membranes.

CASE 5.—An 11-year-old boy sustained a 29% TBS burn caused by a combination of lightning and high-voltage electric power line contact injury. A lightning bolt struck a power line directly above the head of the patient, arced, and knocked him to the ground. The power line then fell on his right shoulder. He lost consciousness, and a bystander gave external cardiac massage, for which the indications were unclear. On arrival at our burn center, he was in moderate distress with a 29% TBS burn of which 20% was full thickness. He was resuscitated, and during his 43-day hospital course all full-thickness burns were excised and autografted. The patient was discharged in stable condition, fully healed, and without neurological deficit.

Lightning Victims Data Summary

Patient No.	Total Body Surface Area Burned, %	Associated Burn	Loss of Consciousness	Associated Injuries and Complications	
				Early	Late
1	23	Clothes ignited	No	Premature ventricular contractions (resolved)	None
2	3	None	No	None	Median nerve neuropathy
3	14	None	Yes	Bilateral lower-extremity swelling requiring fasciotomy	None
4	12	None	Yes	Subendocardial infarction, bilateral ruptured tympanic membranes	None
5	29	High-voltage electric burn	Yes	None	None

Results

A summary of the associated injuries and complications noted in the five patients is presented in the Table. The burned portion of the TBS ranged from 3% to 29% (mean, 16%). Two patients (patients 2 and 4) sustained only partial-thickness thermal injuries that healed spontaneously. In the other three patients (patients 1, 3, and 5), the average full-thickness injury was 12% (range, 4% to 20%). There were no deaths, and the hospital stay ranged from eight through 65 days (mean, 43 days).

Comment

The extent of injury is related to the power, duration, and site of entry and exit of the lightning bolt and to the position and grounding of the victim.²³ The thermal injuries are, to our knowledge, unique with respect to the arborizing or serpiginous pattern of dermal burn (Figs 1 and 2) caused by the splash effect of the arcing lightning bolt. Following natural electrocution by lightning, death may occur as a result of apnea caused by respiratory paralysis. Tausig⁹ and Ravitch et al⁴ emphasized the need for prompt and sustained cardiopulmonary resuscitation no matter how long spontaneous respirations have been absent, if there is no clinical evidence of brain death. Fluid resuscitation, tetanus prophylaxis, and burn wound care should all be accomplished early after the accident.

Treatment of lightning injuries is closely linked to the treatment of associated injuries and complications. Injury to the heart may be reflected by ECG abnormalities, dysrhythmias,

or elevation of cardiac isoenzyme levels.⁵ Of our five patients, only two demonstrated evidence of cardiac abnormality. The first patient had premature ventricular contractions shortly after injury but reverted to normal sinus rhythm on admission to the hospital, as shown by ECG. The fourth patient showed evidence of a subendocardial infarction, confirmed by an ECG, and still present at discharge.

The heart is obviously not the only muscle damaged. Skeletal muscle damage, which may not be visibly evident on initial examination, may subsequently be reflected in the large amount of myoglobin released and presented to the kidneys. Yost and Holmes⁶ emphasized the need to protect the kidneys by administration of osmotic diuretics and alkalinizing the urine. Ehsan et al⁷ described a case of "delayed" gangrene of the right foot of a 32-year-old patient, first evident 11 days after the patient was struck by lightning while standing on a balcony in a thunderstorm.

Another associated injury frequently seen in lightning victims is damage to the ear. Tympanic membrane rupture is the most common injury in this category.⁴ Bilateral tympanic membrane rupture as noted in patient 4 is treated as in any other patient and may be associated with hearing loss.

Critchley⁸ has described the main types of neurological injury attributed to lightning. In particular, the aftereffects that he cited included peripheral nerve lesions, isolated and multiple. Only one of our patients, patient 2, had a peripheral neuropathy develop, evidenced by median

nerve deficit that was confirmed by EMG. This injury was especially unfortunate, since she had been a concert pianist and at the time of the accident was employed as a piano teacher.

A late complication that seems to be related to lightning is the development of cataracts. Noel et al¹⁰ noted that this cause and effect relationship was first described by St Yves in 1722, and that 90 cases had been subsequently reported in the literature by 1972. We noted no visual aberrations in any of the five patients, nor did any cataracts develop while the patients were in our center. However, it is possible that cataracts could have developed after even the longest hospital stay of 65 days.

In summary, victims of lightning injuries may be seen initially with a characteristic arborizing or serpiginous superficial dermal burn pattern. Since the effects of lightning injury may produce coma lasting from several minutes to several days, cardiopulmonary resuscitation should be immediately instituted and continued until the degree of cerebral function can be fully assessed in any individual with no spontaneous respirations at initial examination. Other resuscitative measures include maintenance of vital signs, appropriate fluid administration, tetanus prophylaxis, and antibiotics when necessary. Awareness and prompt treatment of associated complications is also an integral part of the treatment of the lightning-strike victim.

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